PHD SUBJECT FOR DOCTORAL CONTRACT "PRESIDENCE"

Semiconductor nanonets based on ZnO nanowires for flexible electronics

The proposed work with this PhD thesis is part of a larger project whose objective is to address the need to develop functional, reproducible electronic devices whose behaviour is based on nanometric properties and which can be useful for many applications, from energy to biotechnology. An important objective is the development of low-temperature, low-power and environmentally friendly technologies. The devices developed, based on networks of randomly oriented nanowires, called nanonets, are simple to connect to macroscopic objects.

More particularly, the project focuses on innovative technical solutions for the future of smart green electronics by developing a technology able to produce systems that co-host several functionalities. The proposed technology, based on the integration of random NW networks, gives access to numerous capabilities and functionalities, while being applicable at low temperature, on a large scale and producing high-performance, reproducible, flexible and transparent devices and systems. Based on our recent achievements, we strongly believe that the NN-based thin-film transistor (TFT) - technology has the respective advantages of poly-Si, amorphous-Si, oxide or organic material, without their particular drawbacks: poly-Si requires intermediate costs and high temperature for manufacturing and is not flexible while amorphous-Si is not very flexible and requires intermediate temperature manufacturing and both suffer from recyclability issues; organic materials are highly sensitive to oxygen, humidity and UV. Moreover, low-cost, large scale, flexible and transparent technology is an important asset of this NN-based technology.

The overall aim of this work is to break the current limitations of nanomaterial integration into electronic devices and systems, to lay the foundation of a green technology leading to transparent, flexible and efficient systems, compatible with paper substrate and to make it possible at large scale, low cost and low thermal budget along with increasing the reproducibility from one device to another. More specifically, the three specific objectives of this works are:

- to develop the appropriate technology for the production of flexible and transparent devices based on ZnO nanonets,
- to study in depth their physical properties and thus develop new knowledge in the field of percolation
- to develop a functional lab-level demonstrator that takes advantage of nanoscale components and of surface reactivity, along with simple integration on flexible substrates Depending on the experimental results obtained, one of the following application areas will be targeted: optics (UV detection), flexible electronics or gas detection.

Each of these objectives presents challenges specific to their discipline, thus highlighting the interdisciplinary nature of this work:

(1) The **first challenge** concerns the mastery of the material and the development of technologies that result in NWs keeping their particular nanoscale properties -reactivity, surface sensitivity and size effects- while being manipulated by means of technology addressing the microscale.
(2) The **second challenge** is in the development of new knowledge leading to the associated impact and potential. For this, it is essential to combine reliable and reproducible experimental observations with physics based simulations containing minimal initial assumptions.
(3) The **third challenge** relates to the interdisciplinary nature of the project, which requires many very different skills.
(4) Finally, the **fourth challenge** will be raised if the demonstrator, made from low-cost technology, is functional and finds its origin in the nanoscale properties of its basic components

The student recruited will be in charge of the synthesis of ZnO nanowires by sol-gel deposition and hydrothermal growth, their assembly into nanonets by liquid means and the development of the technological process for integration on flexible substrates. Then by means of morphological, structural, electrical and optical characterizations, the properties of ZnO nanonets will be studied in relation to the density of nanowires and the type of nanowires (length, diameter, doping, etc.). Advanced multifunctional characterizations will be used to study the link between mechanical behavior and electrical properties. Finally, an advanced device will be selected, manufactured and studied on the basis of statistical data.

To this end, the student recruited will have skills and knowledge in all or part of the following fields: materials (synthesis and characterization), microelectronic technologies, semiconductor physics, nanoscience, electrical characterization of transistors, surface functionalization.

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Deadline for application: 29/07/2020 for PhD start on 01/10/2020 (funding secured)
Documents to provide: *CV, results M1 and M2 with ranking if possible, letters of recommendation*